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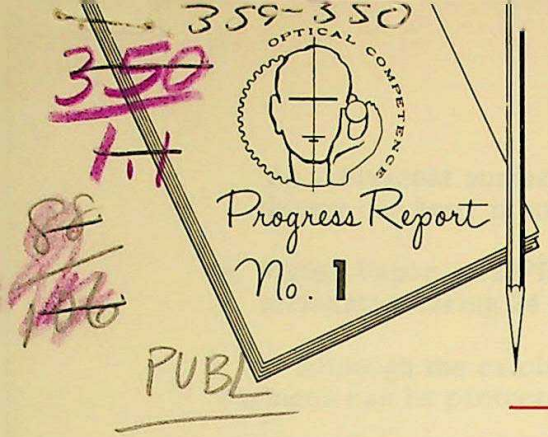

INFRA·RED

BAUSCH & LOMB OPTICAL COMPANY · ROCHESTER 2, NEW YORK

April 17, 1958

SUBJECT: CALCIUM ALUMINATE INFRARED TRANSMITTING GLASSES

INTRODUCTION: Known up to now as Calcium Aluminates, these glasses will be referred to in the future by type designations, such as RIR-10, RIR-11, and RIR-12. Possible additions may be made in the future.

Since these glasses are still in the research stage, their characteristics may be slightly modified. However, they are reasonably well standardized, and possible changes will not be of a major nature. Any major change would establish a new type designation, which would be referred to by an additional number. For your information, the RIR denotes "Research Stage, Infrared." The number identifies the type. When completely standardized and made regularly available, the first R will be deleted.

FORM: The character of these glasses is such that they cannot be reheated and reformed like conventional glasses. Shapes must be cast from the melt. At present, the average yield of a melt is approximately 80 cubic inches of glass. Past experience indicates that flats can be made from RIR-11 and -12 up to $1\frac{1}{2}$" thick, and domes finishing to a 220° hyperhemisphere up to 6" OD can be made from RIR-10. The maximum thickness obtainable from RIR-10, however, is limited to about 1". It is felt that pieces smaller than those indicated can be made with little difficulty while larger pieces (80 cu. in max.) must be treated as a research problem. In designing pieces of maximum dimensions it is suggested that 1/8" of material be allowed for removal on finishing.

DURABILITY: These glasses cannot be given conventional optical glass durability classifications because they react differently to the usual testing media.

In general they are resistant to attack by mildly acidic solutions. Surfaces are attacked by water and water vapor causing some deterioration and substantial reduction in infrared transmission. The following are examples of the behavior of these glasses in various environments:

1. One percent nitric acid at 25°C - pH about 1.0. No obvious deterioration after 24 hours immersion.

2. One percent Calgon* at 25° C - pH about 6.7. no deterioration after 200 hours immersion.

3. Distilled Water

*Tradename Calgon Inc., Sodium hexametaphosphate

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An iridescent surface film forms in one minute. A polished surface is destroyed during one hour immersion. Infrared transmission in the 2-6u region is reduced.

4. Water Vapor - 120°F at 90-95% Relative Humidity. Infrared transmission deteriorates during 24 hour exposure.

Although the calcium aluminate glasses deteriorate in some environments, their surfaces can be protected against attack as shown in the following paragraph.

PROTECTION: Although all three of these glasses deteriorate rapidly in distilled water or under hot humid atmospheric conditions, satisfactory protection can be obtained with either evaporated coatings or by chemical treatment. Magnesium fluoride coated samples have shown no reaction after 144 hours at 120 °F and 95% relative humidity. Chemically treated samples have been tested for 24 hours under the same conditions without deteriorating. Curves showing transmission of RIR-10 and RIR-12 illustrate these conditions. A sample was chosen and measured before coating. This appears as the solid line on the curve. Both sides of this same sample were then coated and its transmission values appear as a short dash line curve. The sample was then exposed to 144 hours at 120 °F, 95% relative humidity, and the results shown as a long dash curve.

You will note that coating enhances transmission and that there is relatively little change in this transmission after exposure. While not shown, similar results may be expected with the RIR-11.

TRANSMISSION: Transmission curves on coated and uncoated samples are attached.

The following table shows the approximate change in infrared transmission with increased temperature of a typical calcium aluminate glass at a thickness of 6.8mm.

Transmission change (T_t - $T_{2.5}$) %

	Wavelength in Microns				
T_t °C	2.0	3.5	4.0	4.5	5.0
200	+2	+2	-2	-4	-5
350	+4	+3	-4	-8	-11
500	+6	+4	-6	-12	-16

T_{25} = Transmission at 25°C
T_t = Transmission at elevated temperature

REFRACTIVE INDEX: The following table indicates the visible and infrared indices of the three glasses:

	RIR-10	RIR-11	RIR-12
0.4861	1.66057	1.67887	1.66647
0.5461	1.65385	1.67109	1.65919
0.5893	1.65022	1.66699	1.65532
0.6563	1.64588	1.66239	1.65085

1.0140	1.6352	1.6506	1.6397
1.1287	1.6334	1.6486	1.6378
1.3620	1.6304	1.6455	1.6346
1.5295	1.6285	1.6435	1.6328
1.6606	1.6271	1.6420	1.6313
1.8131	1.6255	1.6404	1.6297
1.9701	1.6238	1.6386	1.6280
2.1526	1.6216	1.6364	1.6259
2.3254	1.6196	1.6344	1.6239
2.4374	1.6182	1.6329	1.6224
2.577		1.6310	1.6206

PHYSICAL PROPERTIES

Physical Properties of a Typical Calcium Aluminate Glass Compared With Conventional Optical Glass

Property	Optical Crown	Optical Flint	Calcium Aluminate
Young's Modulus	10.2×10^6 psi	7.7×10^6 psi	15.2×10^6 psi
Impact Strength	8100 psi	6690 psi	7490 psi
Breaking Strength CLR*	6860 psi	5420 psi	6500 psi
Fracture Velocity	1487 M/sec.	1179 M/sec.	1559 M/sec.
Density	2.52	3.60	3.07
Coefficient of Expansion	9.9×10^{-6}/°C	8.9×10^{-6}/°C	8.1×10^{-6}/°C
Knoop Hardness	457	359	594

*Constant Rate of Loading

DIELECTRIC CONSTANT AND LOSS TANGENT

Room Temperature Dielectric Constant and Loss Tangent Data Measurements Made at Frequency of 8.6 Kmc

	Dielectric Constant at Thickness			Loss Tangent at Thickness		
Composition	12.65mm	11.43mm	10.21mm	12.65mm	11.43mm	10.21mm
Typical Calcium Aluminate	9.66	9.63	9.56	0.005	0.005	0.009
Optical Flint	7.17	7.26	7.27	0.010	0.007	0.007

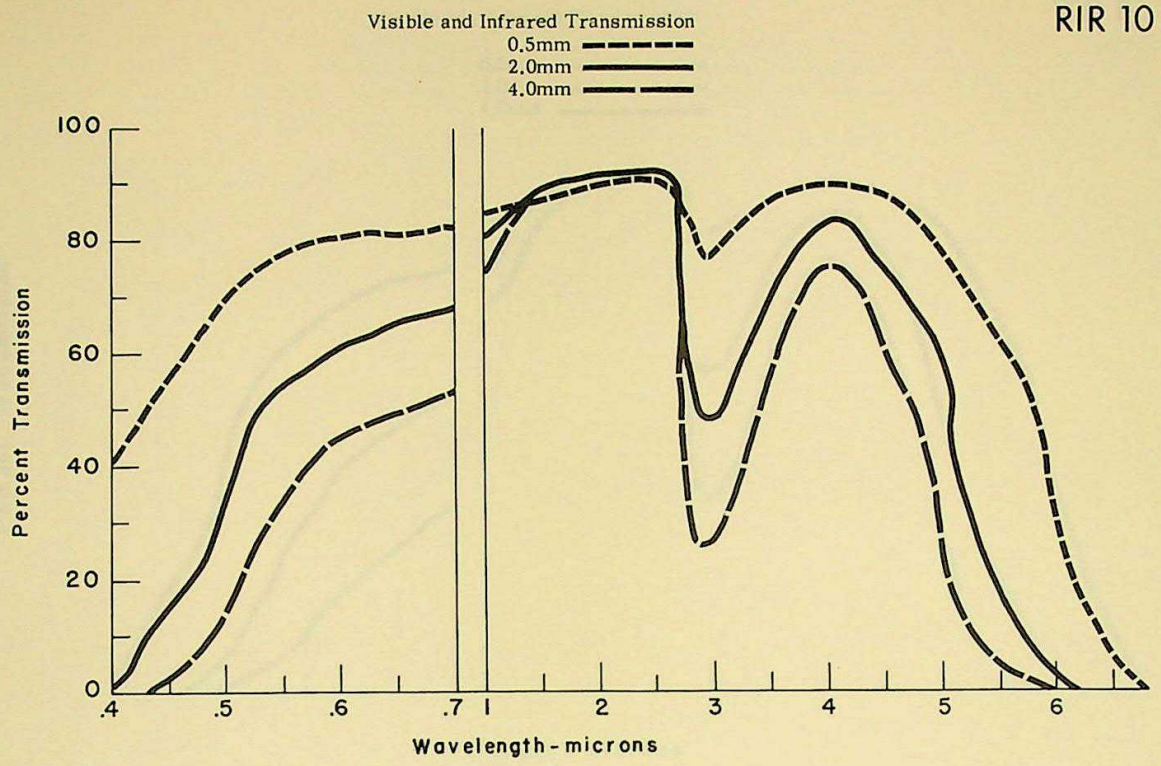
SURFACING: These glasses can be polished by conventional methods. Since surfaces are easily stained by water, cleaning in organic solvents is recommended. Staining is less rapid in slightly acidic media such as Calgon or its equivalent.

USE: RIR-10 is generally recommended for use in IR domes, since it lends itself best for casting to this form. RIR-11 and RIR-12 are somewhat less suited to this form and are best for general shapes. RIR-11 to be used where the slightly longer wavelength transmission is desired. Subsequent development, however, may provide a means for offering the RIR-11 and RIR-12 glasses in dome form.

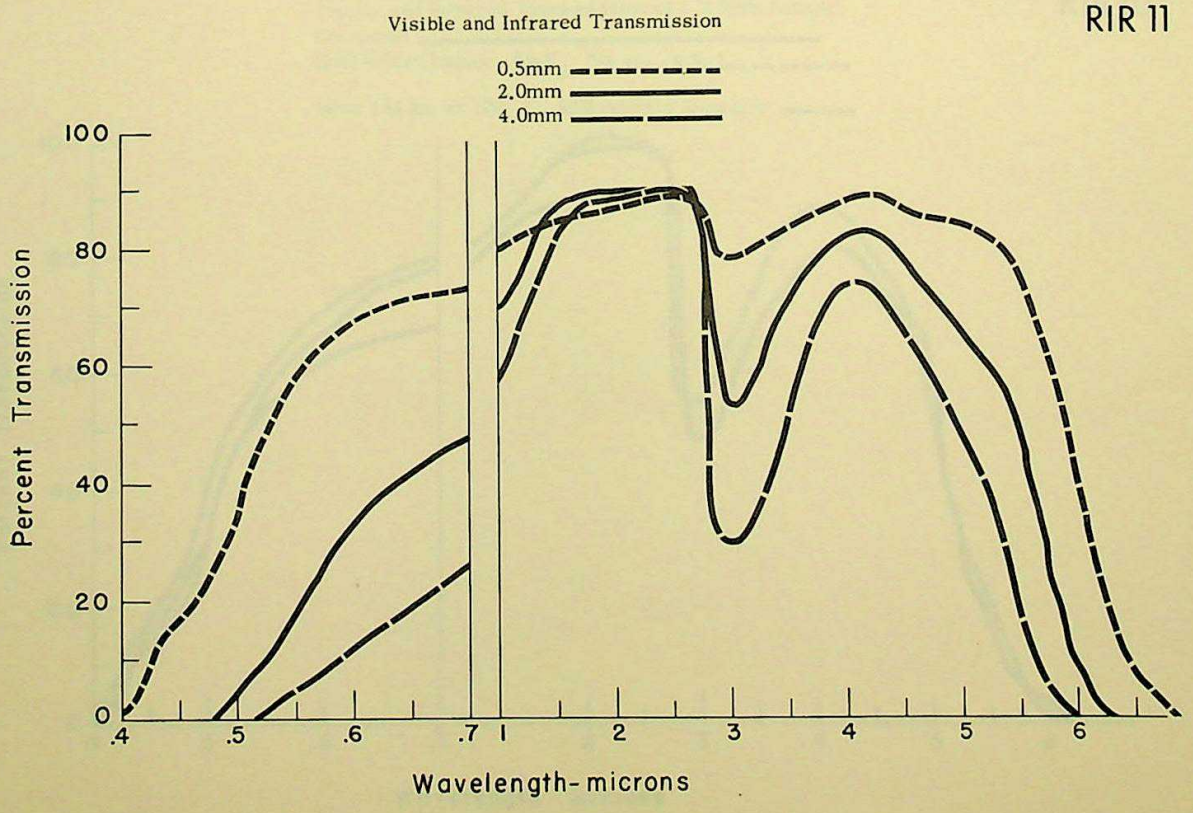
AVAILABILITY AND QUOTATION: Limited quantities of all three glasses are available from laboratory facilities. As previously pointed out, we reserve the right to modify characteristics. Your inquiries are most welcome and prompt attention will be given them. Please give us full specifications on physical dimensions, type, and quantity, and state whether they are to be in finished or rough form.

These data are the latest available up to the date of this progress report. While we reserve the right to change them, they represent a closer approach to final values than any information given heretofore. It is suggested that any information you now have be replaced by that given here. As further steps are taken, a later release will bring you up to date.

RIR 10

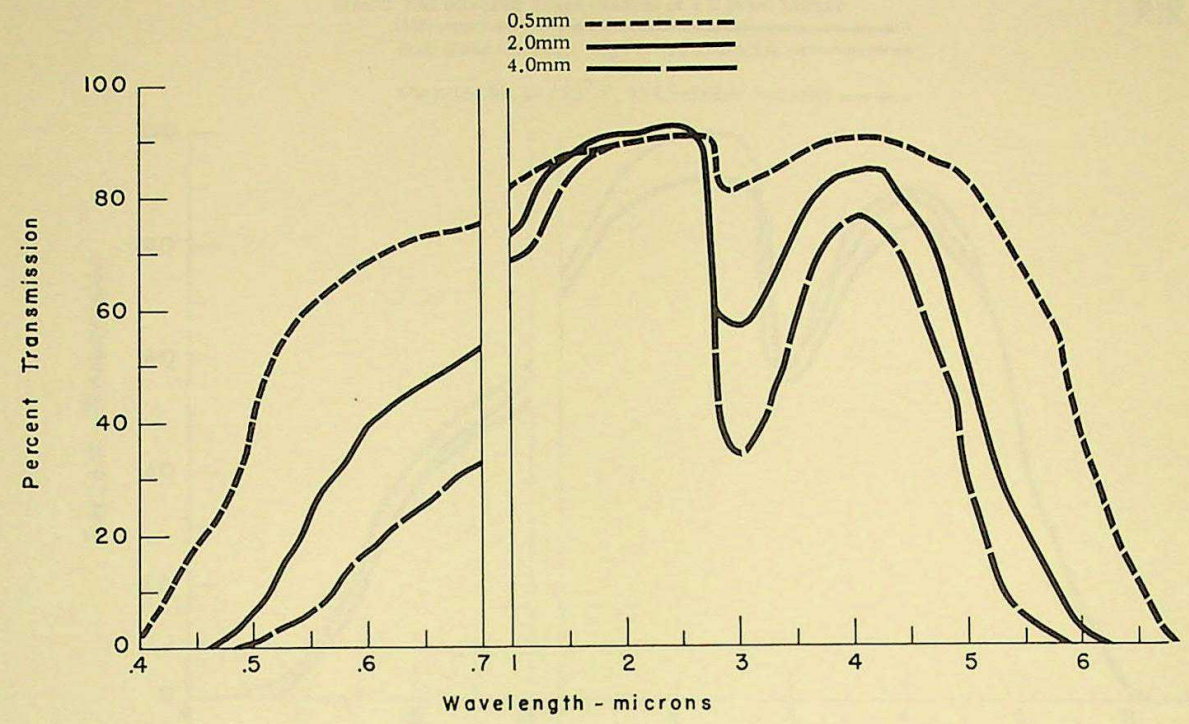

Visible and Infrared Transmission
0.5mm
2.0mm
4.0mm
Percent Transmission
100
80
60
40
20
0
.4
.5
.6
.7
1
2
3
4
5
6
Wavelength - microns

RIR 11


Visible and Infrared Transmission
0.5mm
2.0mm
4.0mm
Percent Transmission
100
80
60
40
20
0
.4
.5
.6
.7
1
2
3
4
5
6
Wavelength - microns

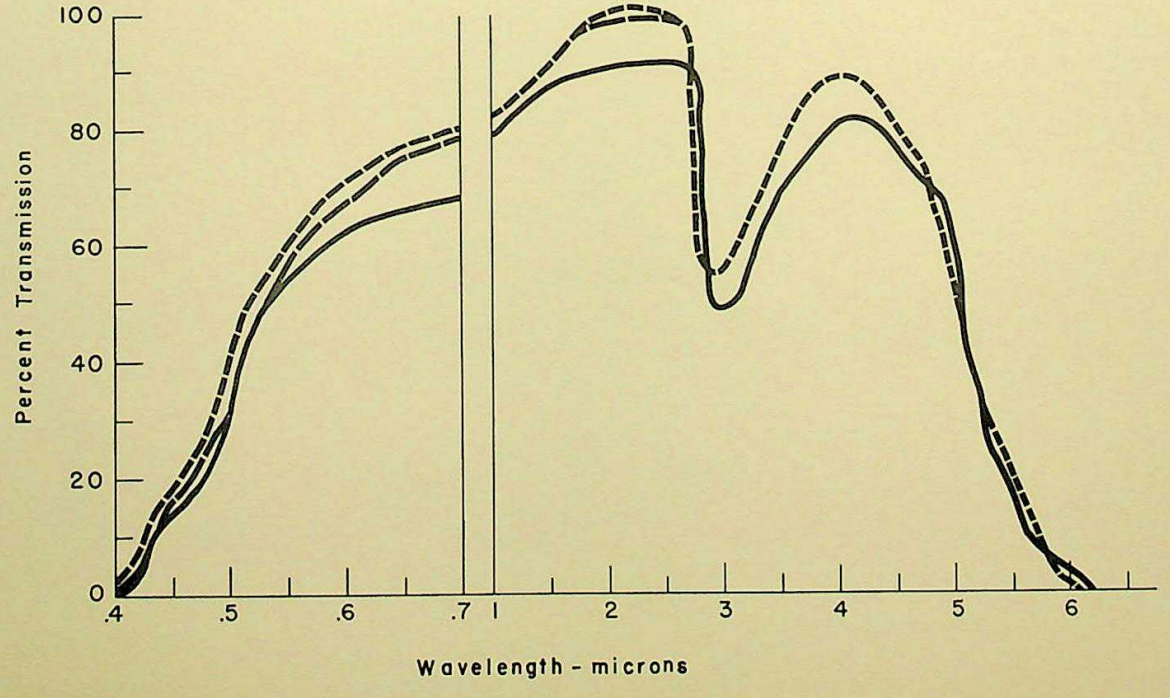
RIR 12

Visible and Infrared Transmission

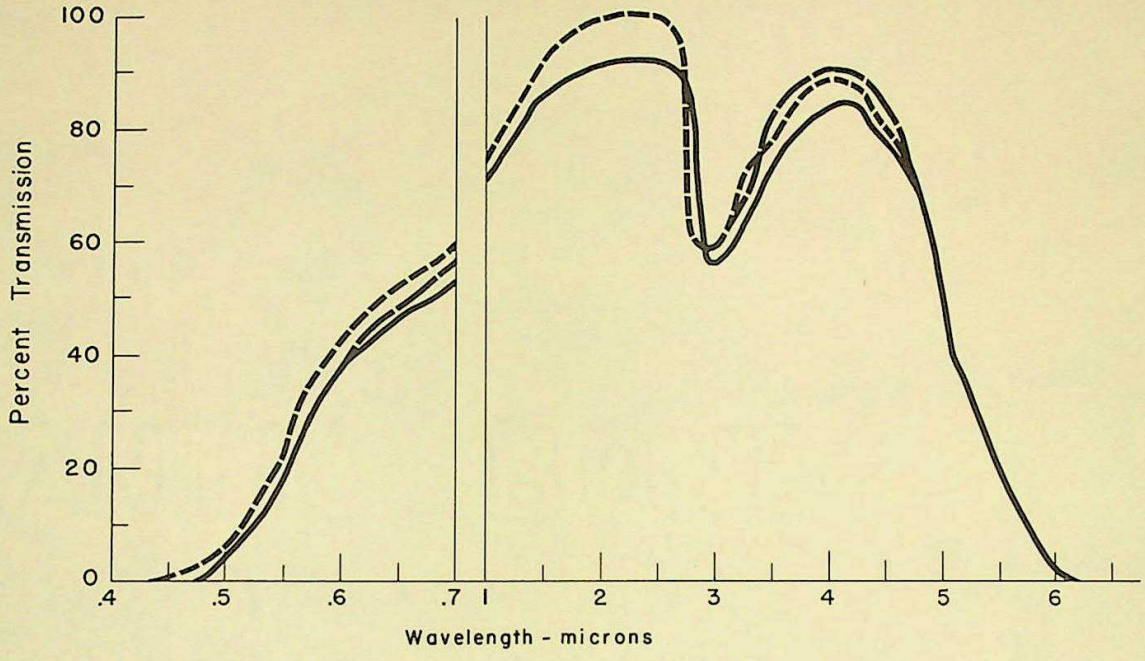


RIR 10

Visible and Infrared Transmission of a 2.0mm Sample
Untreated
Both sides Coated: MgF_2 λ/4 at ~ 4.5μ
After 144 hr. at 120° F., 95% relative humidity



Visible and Infrared Transmission of a 2.0mm Sample
Untreated ——————
Both Sides Coated: MgF_2 λ/4 at ~4.5μ - - - - - -
After 144 hr. at 120° F, 95% relative humidity — — —



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